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Rotational Dynamics

AT Rotational Dynamics (21)

Solve the following problems showing ALL work and CIRCLING your answers. In some cases, the diagram IS part of the essential written work. Each is worth 5 points. A diagram of rotational inertia is included on the last page. I understand that collaboration is "permitted" for this take-home test. All I ask is that you work to understand the material rather than just "write and answer."

1) Determine the torque applied to a screw by a screwdriver if the 35N force is applied tangent to the handle. The handle has a diameter of 3.2 cm. The screwdriver has a length of 14 cm from the end of the blade to the end of the handle. (If you are unable to visual how a screwdriver is used, please ask someone to demonstrate)

$\tau = r \times F_{.016m}$

$\tau = (.032m)(35N)$

$\tau = 1.12Nm$

$\tau = .56Nm$

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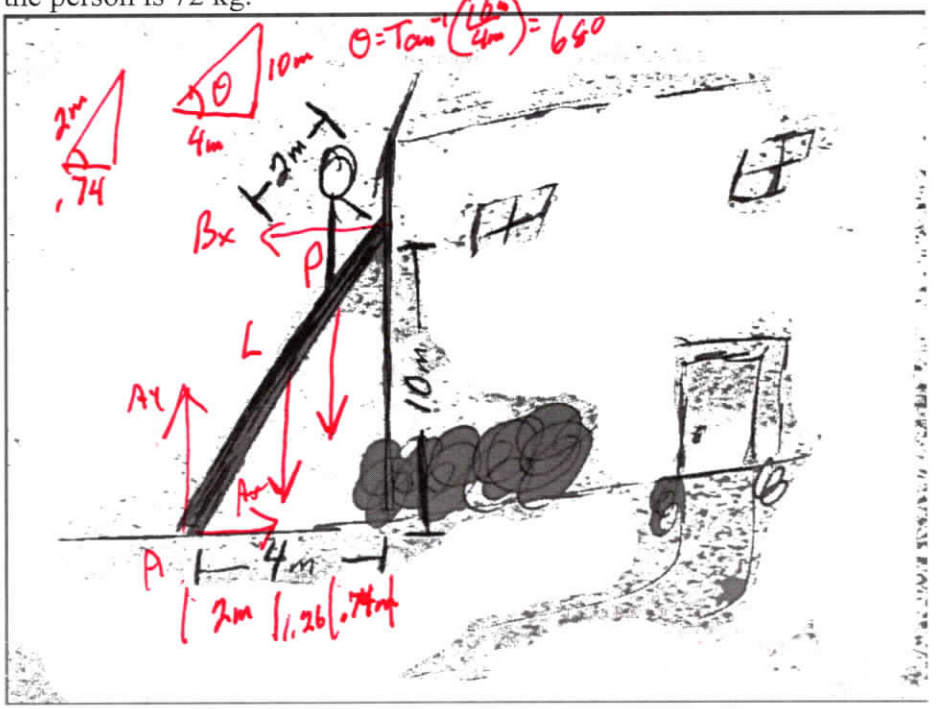
2) Use the diagram to solve this problem. Determine the minimum coefficient of friction needed between the ground the and ladder for the ladder to support the person. Also, determine the reaction at the top of the ladder. Assume the top of the ladder is frictionless as it rests against the house. The mass of the ladder is 40 kg, and the mass of the person is 72 kg.



$\Sigma F_y = A_y - L - P = 0$

$A_y = L + P$

$A_y = (40kg)(9.8 m/s^2) + (72kg)(9.8 m/s^2)$

$A_y = 1097.6N$

$\Sigma T_A = T_L + T_P - T_{B_x} = 0$

$(L)(2m) + (P)(3.25m) - (B_x)(10m) = 0$

$\frac{(40kg)(9.8 m/s^2)(2m) + (72kg)(9.8 m/s^2)(3.25m)}{10m} = B_x$

$307.7N = B_x$

$\Sigma F_x = A_x - B_x = 0$

$A_x = B_x$

$A_x = 307.7N$

$F_f = \mu N$

$A_x = \mu A_y$

$\mu = \frac{A_x}{A_y} = \frac{307.7N}{1097.6N} = .28$

$\frac{A_x}{A_y} = \frac{307.7}{1097.6} = .28$

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3) Determine the work done in the following situation. A flywheel, which has practically all of it's mass on the outer edge, has a radius of 2m, and a mass of 130 kg (Actually, some old-style engines used HUGE flywheels, this large and much larger). The flywheel starts at rest and attains an angular speed of 250 rev/min in a time of 45 seconds.

$W = \Delta KE$

$W = \frac{1}{2} I\omega^2$

$W = \frac{1}{2} mr^2(2\pi f)^2$

$W = \frac{1}{2} mr^2 4\pi^2 f^2$

$W = mr^2 2\pi^2 f^2$

$W = (130kg)(2m)^2(2)(\pi^2)(4.17 Rev/s)^2$

$W = 178306\ J$

$\left(250 \frac{Rev}{min}\right)\left(\frac{1 min}{60 s}\right) = 4.17\ Rev/s$

4) Determine the torque required in the following situation. A flywheel, which has practically all of it's mass on the outer edge, has a radius of 2m, and a mass of 130 kg The flywheel starts at rest and attains an angular speed of 250 rev/min in a time of 45 seconds.

$F = ma$

$\tau = I\alpha$

$\tau = I\frac{\omega}{t}$

$\tau = \frac{I 2\pi f}{t}$

$\tau = \frac{mr^2 2\pi f}{t}$

$\tau = \frac{(130\,kg)(2\,m)^2 2(\pi)(4.17\,Rev/s)}{45\,s}$

$v = v_0 + at$

$v = at$

$\omega = \alpha t$

$\frac{\omega}{t} = \alpha$

$\tau = 302\,Nm$

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5) Determine the power required in the following situation. A flywheel, which has practically all of it's mass on the outer edge, has a radius of 2m, and a mass of 130 kg The flywheel starts at rest and attains an angular speed of 250 rev/min in a time of 45 seconds.

from #3 Work = 1372J

$P = \frac{W}{t} = \frac{1372J}{45s}$ ~~30.5 watts~~ 1783065 3962 watts

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6) Determine the number of rotations made by the wheel in the following situation. A flywheel, which has practically all of it's mass on the outer edge, has a radius of 2m, and a mass of 130 kg The flywheel starts at rest and attains a angular speed of 250 rev/min in a time of 45 seconds.

$v^2 = v_0^2 + 2ax$

$v^2 = 2ax$

$\omega^2 = 2\alpha\theta$

$\frac{\omega^2}{2\alpha} = \theta$

$\frac{(2\pi f)^2}{2\alpha} = \frac{4\pi^2 f^2}{2\alpha} = \frac{2\pi^2 f^2}{\alpha}$ ... Duh...

$x = v_0 t + \frac{1}{2} a t^2$

$x = \frac{1}{2} a t^2$

$\theta = \frac{1}{2} \alpha t^2$

$\theta = \frac{\omega t^2}{2t}$

$\theta = \frac{\omega t}{2}$

$v = v_0 + at$

$v = at$

$\frac{v}{t} = a$

$\frac{\omega}{t} = \alpha$

$f = 4.17 \text{ Rev/s}$

$\theta = \frac{2\pi f t}{2} = \frac{(2)(\pi)(4.17 \text{ Rev/s})(45 \text{ s})}{(2)} = 589 \text{ Rad}$

93.8 Revs

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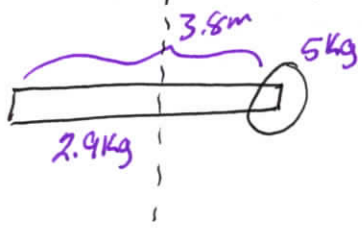
7) A straight, uniformly constructed stick of length 3.8 m and mass of 2.9 kg rotates about it's center. On one side opposite the axis, is a 5 kg mass. Determine the rotational inertia of the object. (No…this really is not a "real" object, or is it intended to be like a real object)



$I = I_{stick} + I_{mass}$

$I = \frac{1}{12} mL^2 + mr^2$

$I = \left(\frac{1}{12}\right)(2.9\,kg)(3.8\,m)^2 + (5\,kg)(1.9\,m)^2$

$I = 21.5\ kg\,m^2$

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8) A set of keys are attached to the end of a 0.7m long lanyard. They are spun around your hand such that the lanyard gets shorter with every rotation. If the keys are moving with a linear speed of 2 m/s at the end of the 0.7m lanyard, determine the linear speed of the keys when the lanyard is only 0.05 cm long.

$$L_0 = L$$

$$I_0 \omega_0 = I \omega$$

$$m r_0^2 \frac{v_0}{r_0} = m r^2 \frac{v}{r}$$

$$r_0 v_0 = r v$$

$$(.7\text{m})(2\text{m/s}) = (.0005\text{m}) v$$

$$2800\text{m/s} = v$$

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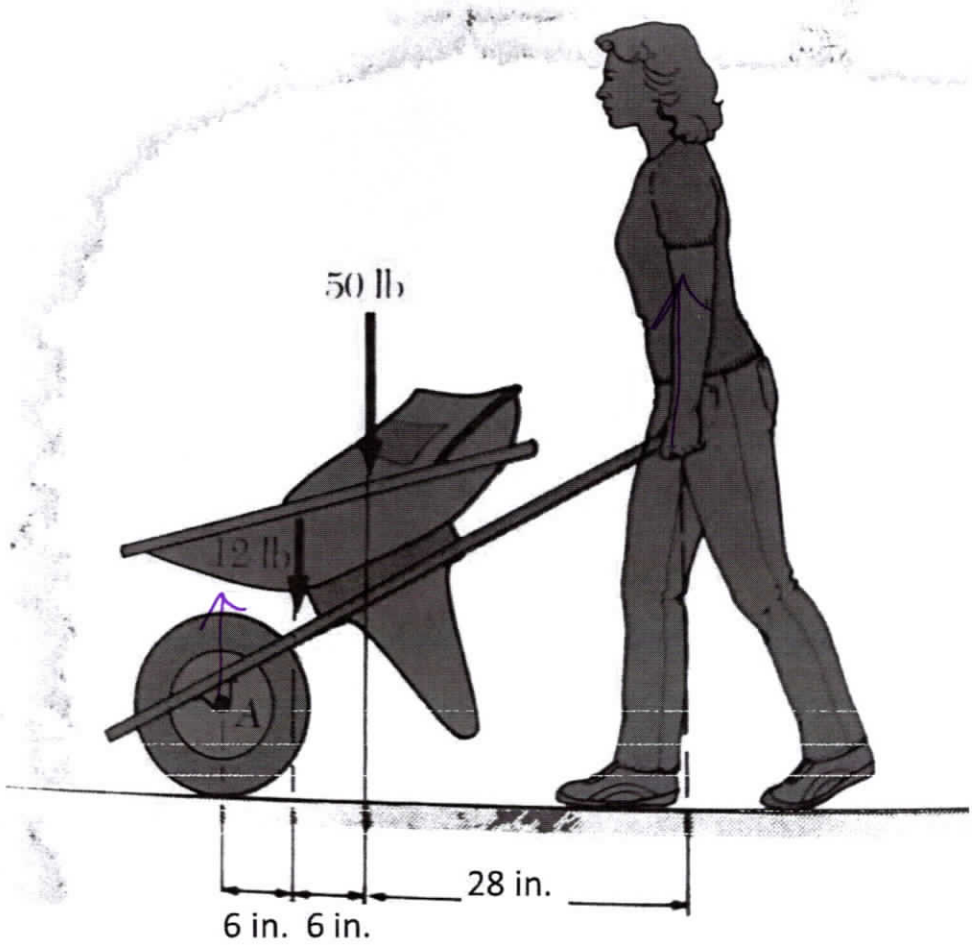
9) Determine the force applied by the person, and the reaction at point "A." The wheelbarrow has a weight of 12 pounds, and the bag of "stuff" weighs 50 pounds.



$\Sigma S_A = (12\text{lb})(6\text{in}) + (50\text{lb})(12\text{in}) - (P)40\text{in} = 0$

$16.8\text{lb} = P$

$\Sigma F_y = A + P - (12\text{lb}) - (50\text{lb}) = 0$

$A = 45.2\text{lb}$

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